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JUN 3 1988

Mr. Alan Robinson
BCM Eastern, Inc.
One Plymouth Meeting
Plymouth Meeting, PA 19462

Dear Mr. Robinson,

Enclosed is a report prepared EPA's contractor, CDM, entitled, "Henderson Road Injection Well Operable Unit Recommendations for Pre-Design Investigations." This report is a combination of the two reports on the saturated and unsaturated zones that I described during our May meeting. I view this report as an extension of the Proposed Plan and not a Significant Change related to the Proposed Plan.

I requested CDM to prepare this report as a supplement to the RI/FS for the Injection Well Operable Unit in order to identify additional work needed to characterize the saturated and unsaturated zones and extent of contamination related to the injection well operable unit prior to final selection of ground water monitoring and recovery wells and prior to determining whether and how to attempt to recover contamination from the unsaturated zone. This work will be completed as part of Pre-Design, Design, and Construction.

The report also proposes an approach to determining whether to proceed with pilot testing for in-situ volatilization, and, conceptually, whether to implement in-situ volatilization after pilot testing. As we've discussed, numerical criteria are not possible to derive at this point. Finally, preliminary costs comprising this additional work are included.

This report should be incorporated into any proposal being prepared by Potentially Responsible Parties in response to the recent RD/RA notice letters that were issued. Please feel free to contact me to discuss any components of this report that raise questions in your mind or to discuss alternate means of conducting Remedial Design activities.

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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Finally, a copy of PA RFP's comments on the final draft RI/FS for the Injection Well Operable Unit are enclosed.

Sincerely,

Geraldyn Downes-Valls
PA CERCLA Remedial Enforcement Section

Enclosure

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DRAFT PRE-DESIGN
RECOMMENDATIONS
FOR THE
HENDERSON ROAD INJECTION
WELL OPERABLE UNIT

HENDERSON ROAD SITE
UPPER MERION COUNTY, PENNSYLVANIA

CONTRACT NO.: 68-01-7331

DOCUMENT CONTROL NO.:

PREPARED FOR:

U.S. ENVIRONMENT PROTECTION AGENCY
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NEW YORK, NY 10278

PREPARED BY:

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JUNE 2, 1988

(19/51)

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June 2, 1988

Ms. Geraldyn Downes-Valls
U.S. Environmental Protection Agency
841 Chestnut Street
Philadelphia, PA 19107

RE: EPA Contract No.: 68-01-7331

Document Control No.:

Subject: Draft Pre-Design Activity Recommendations Report

Dear Ms. Downes-Valls

Camp Dresser & McKee Inc. is pleased to submit the Draft Pre-Design Activity Recommendations Report for the Henderson Road Injection Well Operable Unit. This report recommends investigations to supplement and support the Remedial Investigation/Feasibility Study prepared by Beta, Converse, Murdock, Inc.

Please do not hesitate to call me if you have any questions.

Very truly yours,

Camp Dresser & McKee Inc.



Debra Glover

cc. G. Moore (CDM-FPC)

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Document Control

File

(19/50)

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1.0 INTRODUCTION

1.1 OVERVIEW

The U.S. Environmental Protection Agency, Region III, (EPA) has requested that Camp Dresser & McKee Inc. (CDM) recommend investigations to supplement and support the remedial investigation/feasibility study (RI/FS) prepared for the Henderson Road Injection Well Operable Unit by Betz, Converse, Murdoch, Inc. (BCM). EPA requested that CDM focus its recommendations on the following subjects:

- o Further characterize the vertical and horizontal extent of contamination in the saturated zone,
- o Identify the locations and number of recovery and monitoring wells required for on and offsite ground water pumping during remediation,
- o Further characterize the vertical and horizontal extent of contamination in the unsaturated zone, and
- o Evaluate the cost-effectiveness of implementing an in situ vacuum extraction program at the Henderson Road site.

1.2 FOCUS AREAS AND ACTIVITIES

Recommendations for additional field investigations at the Henderson Road site focus on three areas:

- o The Injection Well,
- o The unsaturated zone surrounding the Injection Well, and
- o The aquifer between the site and the Upper Merion Reservoir.

The recommended investigations are intended to reduce the data gaps that exist after completion of the RI/FS, and to support a Record of Decision (ROD) on the remedy at the site. The purpose of the recommended field activities is to improve the understanding of the fate and transport of contaminants in the unsaturated and saturated zones. Each of the following investigations would contribute significantly to this understanding:

Injection Well Investigation

- o Characterize the source by redrilling the Injection Well (IW) and analyzing waste material (if encountered);
- o Perform downhole logging of the IW or alternate well installed adjacent to the IW,
- o Perform downhole logging of the existing open hole wells in the vicinity of the IW,
- o Collect ground water samples from all existing monitoring wells for volatile organic analysis,
- o Revise the conceptual model of the unsaturated and saturated zones based on the data collected during these additional investigations;

Unsaturated Zone Investigation

- o Site new monitoring wells for the investigation of the unsaturated zone;
- o Install new monitoring wells to monitor the unsaturated zone
 - obtain physical and chemical characteristics of the unsaturated zone conditions,
 - obtain core samples of the unsaturated carbonate strata,
 - obtain and analyze air quality samples from discrete intervals within the unsaturated zone,
 - screen samples of the rock core for the presence of site-related VOCs with an onsite gas chromatograph, and
 - analyze sections of the rock core for selected organic parameters;
- o Vacuum extraction testing;
- o Field tests to evaluate the cost-effectiveness of implementing an in situ vacuum extraction system.

Saturated Zone Investigation

- o Install saturated zone monitoring wells,
- o Collect ground water samples from all monitoring wells (previously existing and newly installed),
- o Revise the conceptual model of the unsaturated and saturated zones to refine design of remedial action,

- o Site ground water recovery wells,
- o Install and hydraulically test ground water recovery wells,
and
- o Perform a ground water treatability study to improve the
conceptual design cost estimates for the ground water
treatment system.

This proposed plan has been developed to satisfy the objectives set forth by USEPA. Due to the complex hydrogeology and contaminant transport associated with karstic carbonate formations, the proposed investigations, although detailed, may not be able to fully meet these objectives. The information obtained, however, will be sufficient to further refine the remedial plans to the degree necessary for remedial design. The field activities can be performed in an efficient and timely manner; however, due to the difficulty of drilling and sampling in fractured carbonates, the proposed investigation will be quite costly.

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2.0 INJECTION WELL INVESTIGATION

2.1 OVERVIEW

It has not been established whether or not the Injection Well is a continuing source of contamination. Existing information indicates that a concrete plug prevents access to the Injection Well at the present time. This plug would be removed and drilling initiated to determine whether waste is still present within the well, and the depth to which the borehole has been sealed. If any waste is encountered in the well, it should be sampled to identify its constituents, and the volume of the waste should be estimated. If a significant amount of waste is identified in the Injection Well, it should be removed and transported to an appropriate treatment, storage, and disposal (TSD) facility as soon as possible. To prevent possible movement of the waste into fractures or into the aquifer, no further drilling of the Injection Well would be performed if a waste source was encountered. If a significant amount of waste is not found, the borehole would be further investigated to determine the depth of intersecting fractures. The Injection Well would also be included in the test program to evaluate the viability of vacuum extraction at the site.

2.2 DRILLING OF THE INJECTION WELL

Opening the well will require that the following procedure be followed. Arrangements would be made to hire a professional driller capable of using an air rotary or downhole air hammer. The driller will need sufficient equipment to make two runs or passes down the Injection Well once the well cap or plug has been removed from the well. Methods for the removal of the well cap, if no straight-forward, would be selected by the driller. The objective of the driller's initial pass will be to monitor for existing remnant waste and to clean the casing and lower borehole to a diameter equal to the internal diameter of the casing. If waste is encountered drilling will stop, and the waste will be sampled and analyzed for Target Compounds List (TCL) parameters, and the volume of the waste remaining in the borehole will be estimated. Should a significant amount of waste not be found a second pass will be made using a variable or expanding diameter bit to enlarge the open hole below the casing and to remove any cement that has seeped into the walls of the borehole. The second pass need only enlarge the borehole diameter sufficiently (approximately 1 to 2 inches) to gain access to the natural formation around the borehole without excessively disturbing the existing fractures or bedrock competency.

Should a decision be made not to open the Injection Well, an alternative option, though less attractive, will be to install a boring or monitoring well within 5 feet of the existing Injection Well. The method used to install this well would be the same proposed for the unsaturated zone monitoring wells, described in a later section.

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2.3 DOWNHOLE LOGGING OF THE INJECTION WELL

Upon completion of the Injection Well restoration, or the installation of an alternate open hole well alongside the Injection Well, the geometric orientation of the existing fractures and solution cavities shall be identified using a downhole logging method. Of the methods that are currently available, an acoustic televiewer would provide the most information. However, this method requires a fluid-filled borehole to operate properly. A downhole television camera, in conjunction with a caliper log, is recommended for use in the unsaturated zone to identify the alignment of the fractures. This information will be compared with core samples collected during the investigation of the unsaturated zone to describe the size and orientation of the fractures. The downhole camera can be used both in the unsaturated and saturated zones of the borehole. Other geophysical methods available do not provide the necessary information in the unsaturated zone.

Depending on the water clarity in the saturated zone, visual identification of fracture orientations may be impaired, requiring the use of an acoustic televiewer to provide geometric orientations (strike, dip, and depth) of the fractures.

Other methods including caliper acoustic velocity (sonic), resistivity, neutron, or gamma-gamma (density) logging could be used to identify the location of fractures in the saturated zone. Problems concerning liability exist, however, with instruments that use a radioactive source (i.e. neutron or gamma-gamma logging), particularly in unstable material such as that encountered during the remedial investigation. These potential liabilities outweigh the worth of the data received; therefore, the use of radioactive geophysical methods is not recommended.

2.4 DOWNHOLE LOGGING OF EXISTING WELLS

Downhole logging should also be performed in each of the existing open hole monitoring wells (RE-205, HR2-195, HR3-255) to attempt to correlate fractures in close proximity to the Injection Well. The correlations will provide a basis for selecting locations for the shallow wells for the unsaturated zone investigation, and possibly the deep wells for the saturated zone investigation. Mapping the discrete fractures between the Injection Well casing and the water table may provide a basis for characterizing the extent of remnant waste and of passages in the unsaturated and saturated zones.

2.5 OTHER INVESTIGATIONS THAT WILL INCLUDE THE INJECTION WELL

Other investigations that will include the Injection Well are described below. At a scheduled time, in coordination with installation of the other on and off-site monitoring wells, the Injection Well or alternate well shall be sampled for ground water, and for organic vapors present in the unsaturated fractured rock above

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the water table. The samples would be analyzed for total VOCs and for specific VOCs of concern. These samplings and analyzes would be performed only if pilot testing is recommended for in situ vacuum extraction at the Injection Well. These investigations are discussed later under the appropriate sections.

Prior to performing the activities described under the unsaturated and saturated zone investigations, ground water samples should be collected and analyzed for volatile organic compounds from the existing monitoring wells and the Injection Well (or alternate well). Floating product, if encountered, should also be sampled and analyzed for TCL organic parameters. The data collected would be used to revise the conceptual model for the saturated and unsaturated zone. Modifications to the proposed investigations, especially the siting of the monitoring well locations, should be made if appropriate.

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3.0 UNSATURATED ZONE INVESTIGATION

3.1 OVERVIEW

The extent of remnant waste in the unsaturated zone and the extent of floating product non-aqueous phase liquid (NAPL) on the aquifer are unknown at this time. The distribution of these wastes may be directly related to each other, and to the specific fractures that intersect the Injection Well.

To identify the presence of remnant waste in the unsaturated zone and characterize the affected volume, a program of test borings and field screening is recommended. Selected test boring would be finished as monitoring wells. The wells will be constructed to monitor the water table for the presence of floating product, and to meet the needs of unsaturated zone air sampling and vacuum extraction testing (if required). This study will attempt to characterize the nature and extent of contamination in the unsaturated zone, but accurate quantification of the waste will not be possible because gross assumptions must be made concerning the porosity of the formation and the fractions of the pore space that are filled with remnant waste, organic vapors, and ground water.

Test boring and well locations are intended to be sited along four (4) transects: the strike of bedding, the strike of the two major fracture/joint patterns identified in the RI, and parallel to the hydraulic gradient of the site (see figure 1). These transects have been selected to represent the principal potential transport routes through the fractured bedrock. The monitoring locations will be sited upgradient and downgradient of the Injection Well, along these lines, at distances of approximately 50 feet and 150 feet from the IW. The need for wells at the approximately 150 foot radius will be reviewed with EPA after the first set of wells are installed.

3.2 DRILLING AND CORE SAMPLING

The test borings will be advanced by the mud rotary or hollow stem auger method in a multistep fashion through the unconsolidated sediment overlying the bedrock surface. At each location, the driller will advance a 8-3/4 inch diameter borehole down to the fractured bedrock surface to allow the installation of a temporary 8 inch diameter steel casing to prevent the overburden from caving in. Split-spoon samples will be collected at 5 foot intervals to identify and record a description of the overburden material encountered. Within the bottom 20 feet of overburden, an undisturbed Shelby tube sample will be collected in accordance with ASTM D1587-83 (1985) for permeability testing.

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The rate of percolation through this layer would have a direct bearing the rate at which the remnant waste in the unsaturated zone would leach into the aquifer. Therefore, the undisturbed samples will undergo laboratory tests for moisture content, dry density, and vertical permeability. The investigation of the Landfill Operable Unit identified the overburden material as a clayey silt, with a permeability ranging between 1.19×10^{-6} and 7.94×10^{-6} cm/sec. This layer could be an effective barrier to infiltrating rainwater and the upward diffusion of gases, increasing the time during which the waste will remain in the fractures. A relatively low permeability barrier overlying the bedrock would improve the performance of vacuum extraction at the site by sealing the unsaturated bedrock zone from the atmosphere.

The test borings will be advanced through the carbonate rock strata using a continuous air coring method. Air coring was used successfully to collect bedrock samples for chemical analysis at the Tyson Dump site. The low air flow required to clear the cutting edge of the coring unit will minimize volatilization of the contaminants. The air reaching the surface will be monitored for VOCs using a flame-ionization detector (FID) instrument such as an OVA. It is likely that the presence of moisture in the air would preclude using a photoionization detector (PID) such as an HNu. A standard NX core barrel will be used, providing a 2-inch core of the material encountered. The borehole created at the outside diameter (O.D.) of the core bit will be cased off by 3-inch O.D. drilling rods as the core barrel advances. The core barrel can be stopped at any length up to 20 feet, and the core brought to the surface for inspection through the drilling rods using a wire line. For this investigation, the core barrel will be advanced to 10-foot lengths. The core will be removed, brought to the surface, and quickly screened for volatile organic compounds (VOCs) using an OVA. Sections that indicate the presence of VOCs will be sampled and analyzed for specific site related contaminants (e.g. toluene, xylenes, 1,1-dichloroethane) using an onsite gas chromatograph (GC). Up to three core samples from each boring will be sent to a local laboratory for TCL volatile organic analysis to confirm the results of the field sampling.

3.2.1 IN SITU GAS SAMPLING

While the core is being screened and sampled, in situ gas samples will be collected using standard gas collection equipment. Sampling tubes will be lowered into the 10-foot section of exposed rock. The section of open hole will be sealed from the surface using an inflatable rubber or mechanical packer. The packer should be set just below the drill rods to effectively seal the interior of the rods, and to reduce the potential for short-circuiting of the air flow along the outside of the drill rods. Several air volumes will be evacuated from the open hole prior to sample collection. Samples will be collected for onsite GC analysis for select volatile organics, or collected in vacuum cylinders and pressurized for shipment to an offsite laboratory for TCL volatile organic analysis.

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This sequence of activities, in which a core sample is collected followed by a gas sample, will be repeated down to the water table. Chemical concentrations in the gas samples will increase as coring proceeds to the water table if NAPL exists on the water surface or if ground water is the contaminant source. Elevated concentrations of volatile organics may be encountered above this point if a source exists in solution features, or along the connecting fractures in the unsaturated zone.

3.2.2 SHALLOW WELL INSTALLATIONS

Only after the core samples have been collected for chemical analysis will physical characteristics be recorded. Characteristics such as lithology, texture, degree of weathering, size and orientation of fractures (if possible) will be recorded, and any remaining core will be reserved as a permanent record.

The borehole will be advanced to a point 10 to 15 feet below the water table. A water sample will be collected from the saturated zone with a bailer, for onsite VOC analysis using a portable GC. At this point the core barrel and rods are to be removed from the borehole to complete the test boring as a monitoring well or to seal the borehole with grout. The decision will be based on the location of the test boring and the results of the field screening program.

For test borings that will be finished as monitoring wells, a second drill rig capable of air rotary or downhole air hammer will be set up on the initial hole to ream the 3-inch open borehole to a larger diameter necessary for the installation of either a 4-inch open-hole, or 4-inch cased well. The determining factor in selecting an open-hole versus a cased well will be the stability of the formation. Should the bedrock be stable enough to remain an open hole, the 4-inch casing shall be set 10 feet into the unsaturated competent rock and grouted in place as the 8-inch temporary casing is removed. If the bedrock is not stable enough to allow an open hole monitoring well, then casing and screen materials will be required. Sufficient screen will be required to submerge a 10 to 15 feet section into the water table for ground water sampling purposes, and to screen a minimum of 30 feet above the water surface for the purpose of vadose zone gas sampling, and delineating the effectiveness of a vacuum extraction system (if required). Following development of the wells, and a 2 week period to allow conditions surrounding the well to equilibrate, the wells will be checked for floating product.

3.2.3 SHALLOW WELL CONTINGENCIES

The total number of shallow water table wells to be installed will be determined in part by the nature and extent of the bedrock fractures encountered and the results of the screening program. Should VOC

contamination be found in the test borings installed at the 50-foot radius, then additional borings and wells shall be installed at in the 150-foot radius. It is anticipated that between 4 and 8 shallow wells will be installed in order to delineate the extent of remnant waste and remaining NAPL near the Injection Well.

At the conclusion of the field screening program, all data will be compiled, and the extent and nature of waste material in the unsaturated zone will be evaluated to decide whether sufficient volatile material exists that may be removed by in situ vacuum extraction. If the decision is made to investigate this technology, a series of tests will be performed using the existing and newly installed wells to identify the extent of interconnected airflow in the unsaturated zone and to obtain preliminary estimates of the VOC removal rates that may be achieved. The test program is described below.

3.3 ONSITE TESTING OF VACUUM EXTRACTION SYSTEM

3.3.1 OVERVIEW

The decision to implement pilot scale testing of a vacuum-extraction system (VES) at the Henderson Road Injection Well Operable Unit (HRIWOU) should be based on an evaluation of the extent of VOC contamination in the unsaturated fractured bedrock, and on preliminary testing of a VES at the site. It is necessary to estimate the extent of VOC contamination in the unsaturated zone to decide if there is a potential problem at the site that may be remediated using a VES. The onsite tests would be performed to provide a preliminary evaluation of the VOC removal rates and treatment costs. If VES treatment appears to be reasonably cost-effective compared to removal of VOCs by treatment of ground water, the data would be used to a design pilot test program to refine the projections of the time required to achieve remedial goals, the performance of the process train, and the costs of the remediation.

3.3.2 EVALUATION OF THE EXTENT OF VOC CONTAMINATION

The first critical consideration in deciding whether to pilot a VES is the evaluation of whether there is a significant contamination problem that can be remediated by vacuum extraction. This evaluation can be made by estimating the relative quantities of VOCs in the unsaturated zone, fractured rock, and ground water within a test plot that is typical of the area around the Injection Well. CDM proposes that the test plot include the Injection Well, the wells installed during the unsaturated zone investigation, and the existing wells RE-205, and HR-2-195, which are screened across the ground water table.

The concentrations of VOCs measured in the cores, gasses from the vadose zone, and ground water collected during installation of the unsaturated zone monitoring wells would be used to calculate the total

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mass of VOCs in each matrix within the test plot. Any assumptions required to estimate the volumes of each matrix should be consistent with those made in the RI, and with the known characteristics of the fractured carbonate rock in that area. The resulting estimates will be of low accuracy, suitable only for comparing the relative significance of the VOC loads present in each matrix.

If the estimated mass of VOCs in the fractured bedrock and the vadose zone gas is too small present a significant threat to ground water quality then treatment of the unsaturated carbonate rock will probably not be justified. If contamination in the bedrock and soil gas presents a significant threat, or exceeds some other criterion set by EPA, treatment of the unsaturated zone may be justified, and field testing of a VES should be considered.

3.3.3 PRELIMINARY ONSITE TESTING OF VACUUM EXTRACTION

If significant amounts of VOCs are present in the unsaturated carbonate strata, a series of preliminary field tests would then be performed to estimate the area of influence of each well, and the initial VOC removal rates that may be achieved. The data obtained from these tests would be used to evaluate the costs of removing the VOCs from the bedrock by vacuum extraction relative to the costs of removing the same quantity of VOCs from the ground water. This comparison is based on the assumption that VOCs in the unsaturated zone would eventually migrate to the ground water. If vacuum extraction provides contaminant removal at comparable or lower cost than ground water treatment, further piloting of a VES may be appropriate.

Onsite testing would be performed using a portable vacuum extraction unit and well manifold system similar to that shown in figure 3. The principal process units would be a water-air separator to condense the water vapor extracted from the unsaturated zone, a blower to maintain a negative pressure at the extraction well heads, and a series of vapor-phase activated carbon units to remove VOCs from the extracted gas.

The wells within the test plot would be connected to a manifold system originating at the VES. The manifold system would include annubars at each well to measure air flow rates at the well head, a venturi at the VES intake to measure total flow rate, and valves at each well head to isolate them from the manifold as needed. All wells at the site, including those outside the test plot, would be fitted with manometers to monitor the gas pressure within the well.

3.3.4 VACUUM EXTRACTION TESTING PROCEDURES

During this preliminary investigation program, each well within the test plot would be tested individually according to the following procedure:

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- o Before beginning each test, vadose zone gas pressures and ground water elevations would be measured in each well to identify baseline conditions
- o All wells except the test well would then be closed to the atmosphere, and the vacuum blower started
- o The pressure in the test well would be adjusted to a level that could be expected during full scale operation
- o The gas pressures and ground water levels within the test well, and all monitoring wells, would be measured at regular time intervals to estimate the pressure gradients and area of influence developed around the test well.

Because the fractured carbonate rock may result in a complex local air flow system, each well should be tested individually to identify the extent to which they influence each other. Several rounds of tests would be required to explore the effects that varying the extraction pressure, or simultaneously extracting several wells, would have on the area influenced and on contaminant removal rates.

3.4 VACUUM EXTRACTION SAMPLING AND INTERPRETATIONS

Throughout the duration of each test, samples of the extracted gas would be collected at the well head of the test well and analyzed for total VOCs, and for particular VOCs of concern. The gas flowrate and temperature would also be measured. Gas samples will be screened onsite with a field GC to provide data to guide test performance. Each sample will then be analyzed by laboratory GC to provide data of acceptable quality for the cost-effectiveness evaluation. The preliminary test program will take place over a short time frame, therefore analysis of the extracted gas should be performed at an offsite laboratory to avoid the mobilization costs associated with an onsite laboratory. Because both chlorinated and non-chlorinated VOCs are present, analysis with both a flame-ionization detector (FID) and electron-capture detector (ECD) would be preferred.

The data on vadose zone gas pressure, adjusted for changes in the ground water elevation, would be used to estimate the area influenced by each well and identify preferred flow paths between wells. Monitoring wells outside the area of influence of a test well would be identifiable by the relatively large pressure gradients that could be maintained between them and the test well.

Initial removal rates of VOCs would be estimated for each well by plotting the cumulative VOC removal during each test versus the intervals between samples. The slope of the resulting curve would approximate the initial removal rate.

The estimates derived from the field data would then be used to devise a reasonable hypothetical treatment scenario wherein vacuum extraction is applied to remove a given mass of VOCs from the unsaturated bedrock

within the test plot. Cost estimates based on this scenario would be compared to the estimated costs of removing the same quantity of VOCs from the ground water within the test plot using the ground water treatment system proposed for the site. This is a screening step intended to evaluate whether use of a VES, in addition to the proposed ground water system, is clearly less cost-effective than removing the additional VOC contamination from the ground water. If the additional treatment costs are comparable, a more detailed VES pilot test should be considered.

In a karst environment, steady-state flows and pressures will assert themselves shortly after the start of the test. Therefore, a period of 4 weeks or less is projected for this test program, allowing several rounds of testing to be performed at each well within the test plot.

Rough estimates of the costs for this test program are presented in Attachment 2.

3.5 LONG-TERM PILOT STUDY OF VES

If the short-term tests indicate that vacuum extraction appears to be a viable option, a long-term pilot study would then be performed. The long-term pilot study should be of sufficient duration, and produce enough relevant data, to allow accurate projections of the time required for cleanup, the performance of the treatment system, and costs of the treatment. The study would involve treatment of the entire test plot using the portable VES, and may last anywhere from 2 to 8 weeks. The study would focus on estimates of the overall removal rate for VOCs, and evaluation of effectiveness of the VES process train.

The test program is briefly described below. A more detailed design of the pilot study and cost estimates for its execution must be based on data from the preliminary tests.

The initial VOC removal rates estimated during the preliminary tests are likely to be higher than the rates that could be achieved toward the end of the treatment period. Data from tests conducted over a longer period of time are needed to produce a reasonable projection to be made of the times needed to achieve various removal criteria. These projections will still be very rough estimates, but will be more representative of actual operating conditions than those made from estimates of the initial removal rate. Test wells for this study would be selected to achieve optimum removal of contaminants, based on the areas of influence, zones of contamination, and initial removal rates estimated from the drilling and sampling programs, and data from the short-term vacuum extraction test. Gas flow rates and VOC concentrations would be monitored at the extraction well heads throughout the test period. Unsaturated zone gas pressures and ground water elevations would be monitored at all wells within the test plot. Overall removal rates would be estimated from a plot of cumulative VOC removal versus time.

A performance evaluation of the VES process train would be needed to support estimates of the full-scale treatment costs. This evaluation would focus on the VOC removal or loss in each major component of the process train. VOC concentrations would be monitored in the process air entering and exiting the water-air separator, blower, and activated carbon units. VOC concentrations in the condensate from the separator, and in the spent activated carbon would also be monitored. The analytical data would be used to calculate process efficiencies, based on VOC mass balance, and to estimate the costs of carbon replacement, regeneration or disposal, and of condensate disposal.

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4.0 SATURATED ZONE INVESTIGATION

4.1 OVERVIEW

The existing information on the saturated zone, while sufficient to evaluate an onsite pump and treat alternative in the FS, should be supplemented before selecting well locations and estimating pumping rates to capture contaminated ground water offsite for treatment. The vertical and horizontal extent of site-related contamination and the distribution of floating product have not been sufficiently characterized to date. The FS has been completed using a consistent set of assumptions, but specific areas must be characterized before the alternatives can be finalized.

4.2 ADDITIONAL MONITORING LOCATIONS

Additional locations proposed for monitoring well clusters are presented in figure 3. The following locations are proposed to identify the nature of contamination and its vertical and areal extent:

- o to the east and west along the strike of formation,
- o at the existing HR-5 and HR-3 clusters (primarily for vertical extent of contamination), and
- o between the site and the Upper Merion Reservoir along surface lineaments that are likely to be associated with major joints and fractures.

In addition, a well cluster is proposed to further characterize the water quality upgradient of the Injection Well.

Two monitoring well clusters (one east of the existing cluster HR-2 and the other between the Injection Well and the Hubing Well) will be installed along the formation strike to characterize the extent of contamination along this axis. These locations are felt to be important because extremely high levels of contaminants (including floating NAPL) have been identified at the HR-2 cluster, and literature indicates that the most permeable fractures are parallel to the bedding plane.

Additional monitoring wells are recommended to supplement existing well clusters HR-3 and HR-5. At existing well cluster HR-3, extremely high concentrations of VOCs were detected as deep as 295 feet; it is important to determine if contaminant concentrations are increasing with depth and to determine the vertical extent of contamination.

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Although a well has not been screened across the water table at this location, one is proposed as part of the unsaturated zone investigation. One deep well is proposed at a depth of 400 to 450 feet. Two additional monitoring wells are also proposed at the location of HR-5-192 because the remedial investigation indicated that the relatively low levels of contaminants detected may be due to the shallow nature of this well.

One upgradient clustered well location is proposed along Church Road to monitor the ground water entering the site. This cluster should be located directly upgradient of the site, between the Injection Well and location HR-2, and the Kessler site. This cluster should not be located along a major fracture that intersects the Injection Well. Waste transported through a major fracture in the unsaturated zone may have had an effect on water quality, as was observed at location HR-1.

Three additional downgradient well clusters are proposed along surface lineaments that are likely to be associated with major joints and fractures between the site and the Upper Merion Reservoir (UMR). Monitoring wells have not been recommended further downgradient because water quality may be too strongly influenced by converging flow at the UMR to identify the contribution of contaminants originating at the site. It is also felt that it would be difficult to design an effective capture system past this point because of the effects of pumping at the UMR.

The recommended well locations should be monitored at distinct water bearing zones at the approximate depths of 200 feet, 300 feet, and 400 feet to 450 feet below the ground surface (bgs). The remedial investigation has established that significant contamination within the saturated zone has reached depths approaching 300 feet bgs onsite, and that contaminant concentrations downgradient of the Injection Well increase with depth. The RI has also identified a downward vertical hydraulic gradient at the site, and steeply dipping fractures (45° to 85°) which provide the impetus and pathway for the downward migration of contaminants. At this time, however, the total depth of the contaminant plume is unknown.

4.3 MONITORING WELL INSTALLATION AND SAMPLING

Monitoring wells will be drilled by the air rotary method using procedures similar to those used in the RI. The permeable fracture zones will be identified by the driller as the borehole is advanced. The returning air flow will be monitored with an OVA to identify potential VOC contamination. Monitoring wells should be constructed with casing and well screen to avoid possible cross-contamination.

The new and existing monitoring wells, in addition to the PSWC-Test Well and the McIlvain Well, should be sampled prior to design. Field measurements of pH, Eh, temperature, and specific conductance should be made when the wells are sampled. A round of water levels should also be collected prior to sampling. Samples should be analyzed for Target Compound List (TCL) parameters and conventional water quality

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parameters. Conventional parameters include BOD⁵, COD, ammonia-N, phosphate, total suspended solids, total solids, total dissolved solids, oil and grease, alkalinity, and hardness. The need for conventional parameter analysis is discussed in a separate report on ground water treatment pilot testing requirements. The analytical results of samples from the new wells will provide additional information on the extent and distribution of the contaminant plume. Samples from the existing wells will determine if contaminant concentrations have substantially changed between the RI and design phases.

4.4 SITING AND TESTING GROUND WATER RECOVERY WELLS

At this point the results of the additional investigations should be reviewed to modify the conceptual model of contamination to reflect the existing conditions. Based on this model, preliminary locations should be selected for the offsite recovery wells. The locations should not be finalized until a pump test has been conducted to evaluate the hydraulic system offsite, and in the deeper monitoring intervals.

The pump test conducted during the RI, while limited in its area of influence, provided a good basis for estimating the pumping rates of onsite recovery wells at depths up to 300 feet bgs. Because of the anisotropic nature of the aquifer, the hydraulic system offsite and in the deeper monitored zones should be tested before finalizing the onsite and offsite recovery well locations. In the FS, BCM proposed to test each recovery well before initiating a pump and treat alternative. CDM recommends that a pumping well be installed at one of the onsite recovery well locations during this additional investigation. A pumping test should be conducted, and water levels in the newly installed offsite, and deep onsite wells should be monitored. Selected wells from the RI should also be monitored, as equilibrium conditions were not reached during the 24-hour test conducted during the RI. The test should be run for an extended period of time (72 to 144 hours), under actual operating conditions. The test should establish equilibrium water level conditions in the pumping well to determine if the pumping rates can be maintained, if fractures will be dewatered, and if the total area that will be influenced by the withdrawal of water. It may be necessary to install additional observation wells to properly evaluate the effects of the recovery system in the aquifer. The preliminary recovery well locations and pumping rates should be reviewed and modified, if necessary, based on the results of this test.

Once recovery wells have been installed and hydraulically and chemically tested, the treatability and pilot testing, as discussed in a separate report on ground water treatment piloting, should be implemented.

5.0 INVESTIGATIVE SYNOPSIS

These investigations have been developed to satisfy the following objectives:

- o Correlate bedrock fractures in the immediate vicinity of the Injection Well to characterize the distribution and flow passages of remnant waste in both the saturated and unsaturated zone.
- o Determine the nature and extent of remnant waste in the saturated and unsaturated zones, along with the characterization of NAPL on the water table surface.
- o Characterize the lateral and vertical extent of ground water contamination and determine the vertical and lateral groundwater gradients.
- o Perform preliminary tests that will help determine the effectiveness of VES.

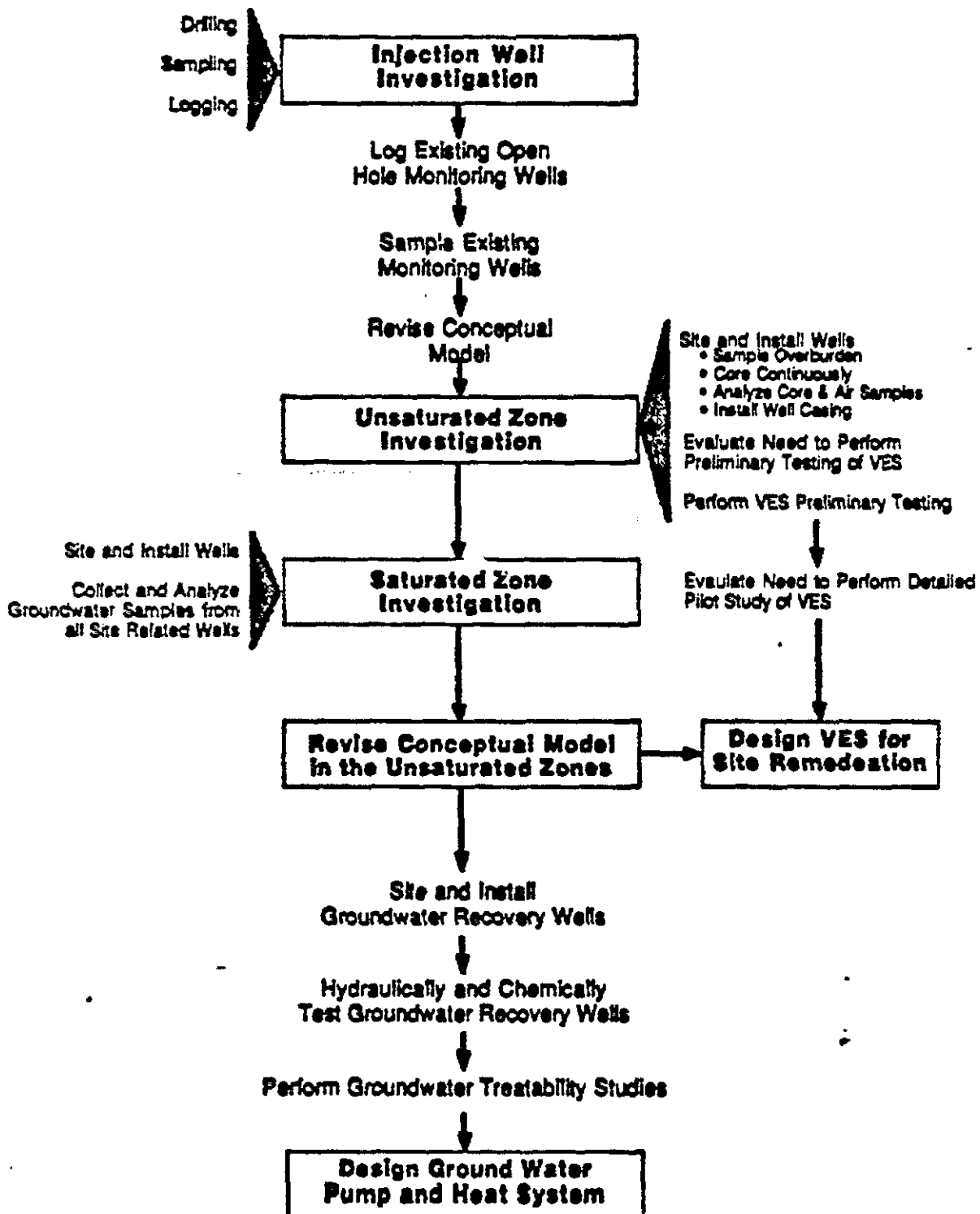
While these investigations will help to clarify the nature and extent of contamination and to support design of an effective remedy for contamination at the site, all of the objectives presented may not be completely satisfied due to the complex nature of the site.

(FS/RG/19/35)

ATTACHMENTS

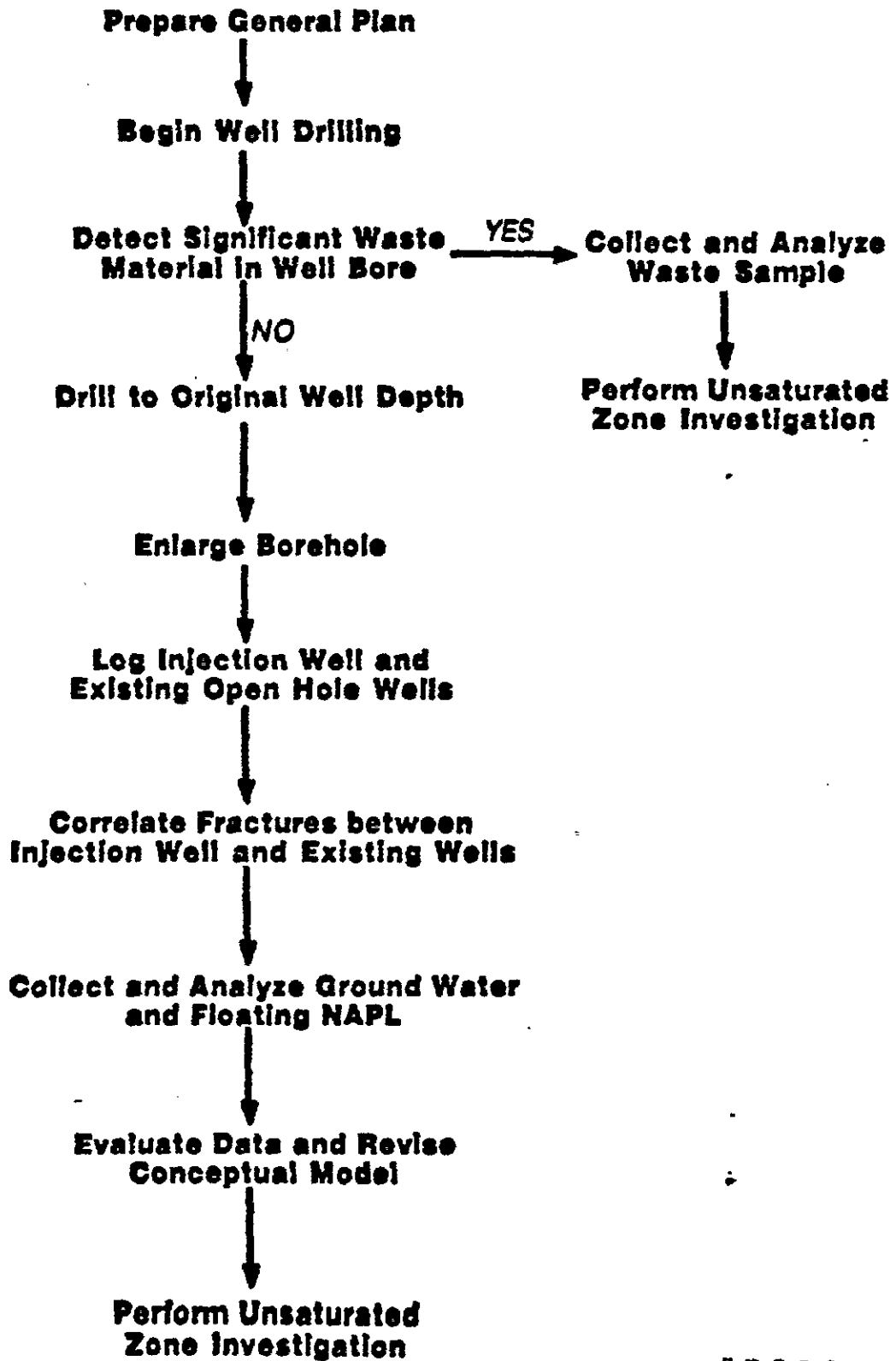
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Overview of Predesign Activities Progress of Events

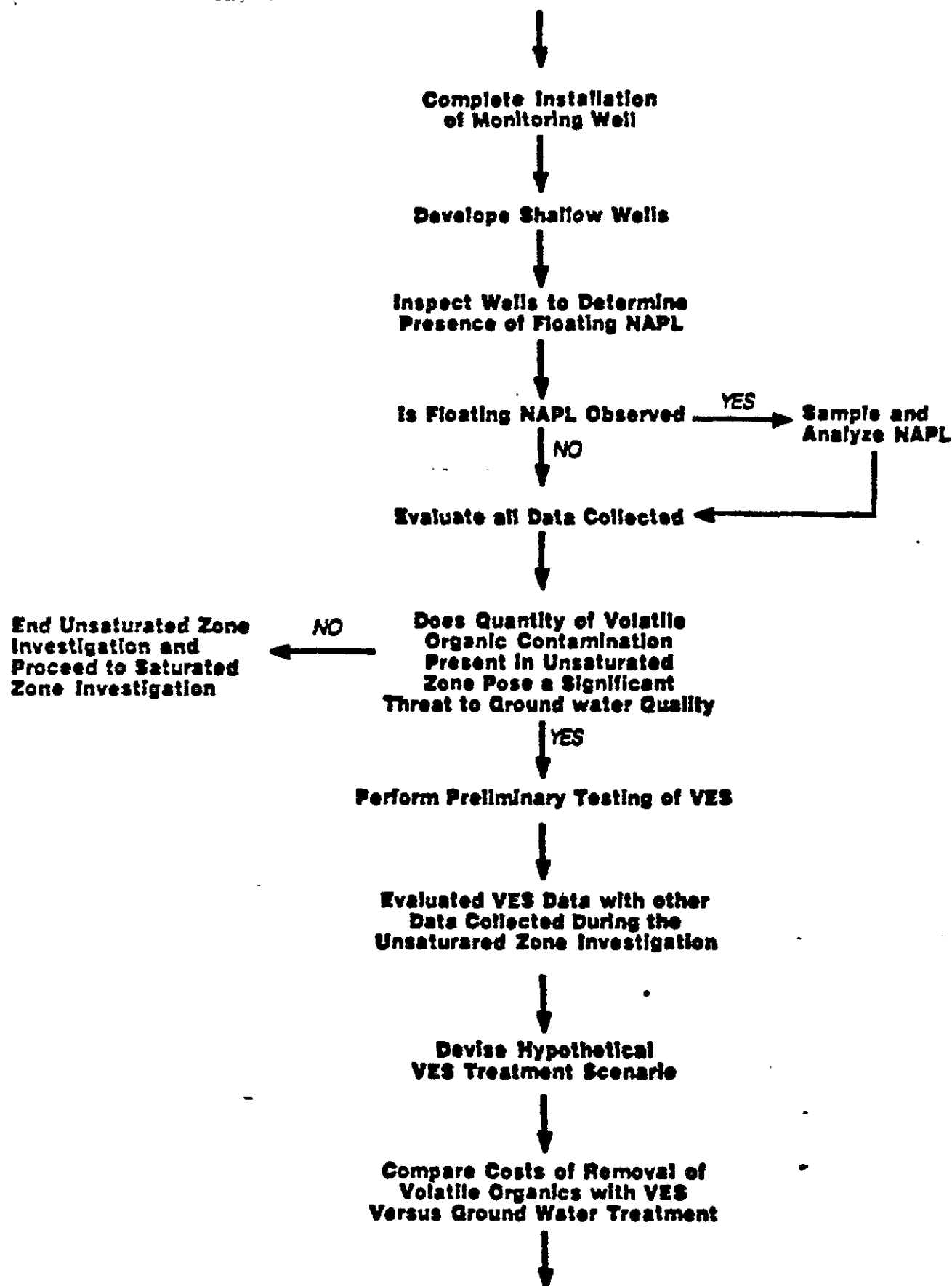


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Detailed Outline of Progress of Events for the Injection Well Investigation



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AR302247

**Are Costs of Removal by
VES Less than or
Comparable to
Groundwater Treatment**

NO

**Terminate for the
Investigation of VES
is not a Cost Effective
Remedial Measure**

YES

**Develop Plans for a
Longterm Pilot Study of
VES**

**Perform Pilot Study of
VES**

**Evaluate VES
Performance and
Recommend Whether
VES is a Viable Remedial
Measure**

NO

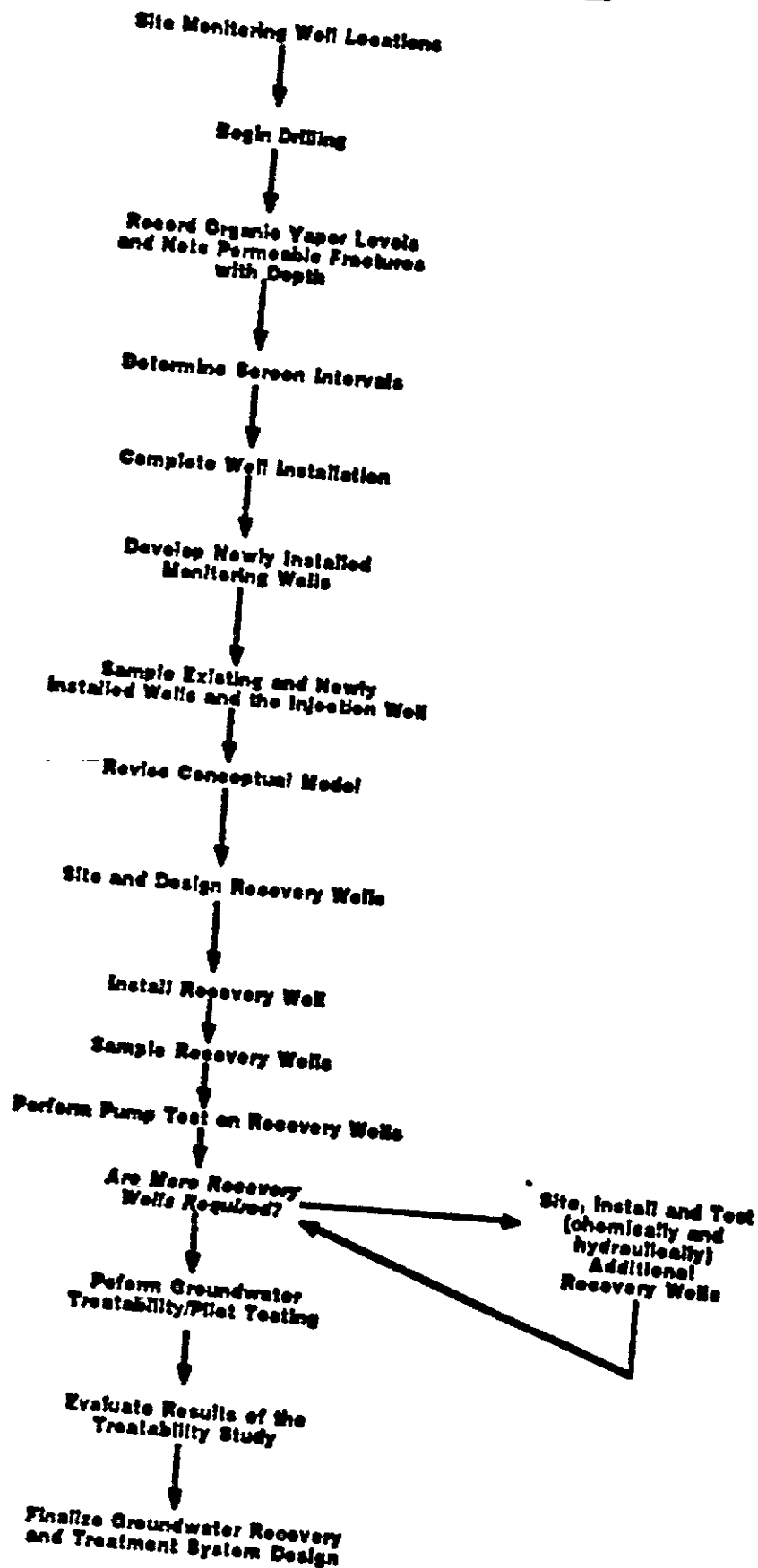
Terminate Analysis

YES

Design VES System

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Detailed Progress of Events for Saturated Zone Investigation



AR302249

is of Events for Investigation

locations

1986

o, install and Test chemically and hydraulically Additional recovery Wells

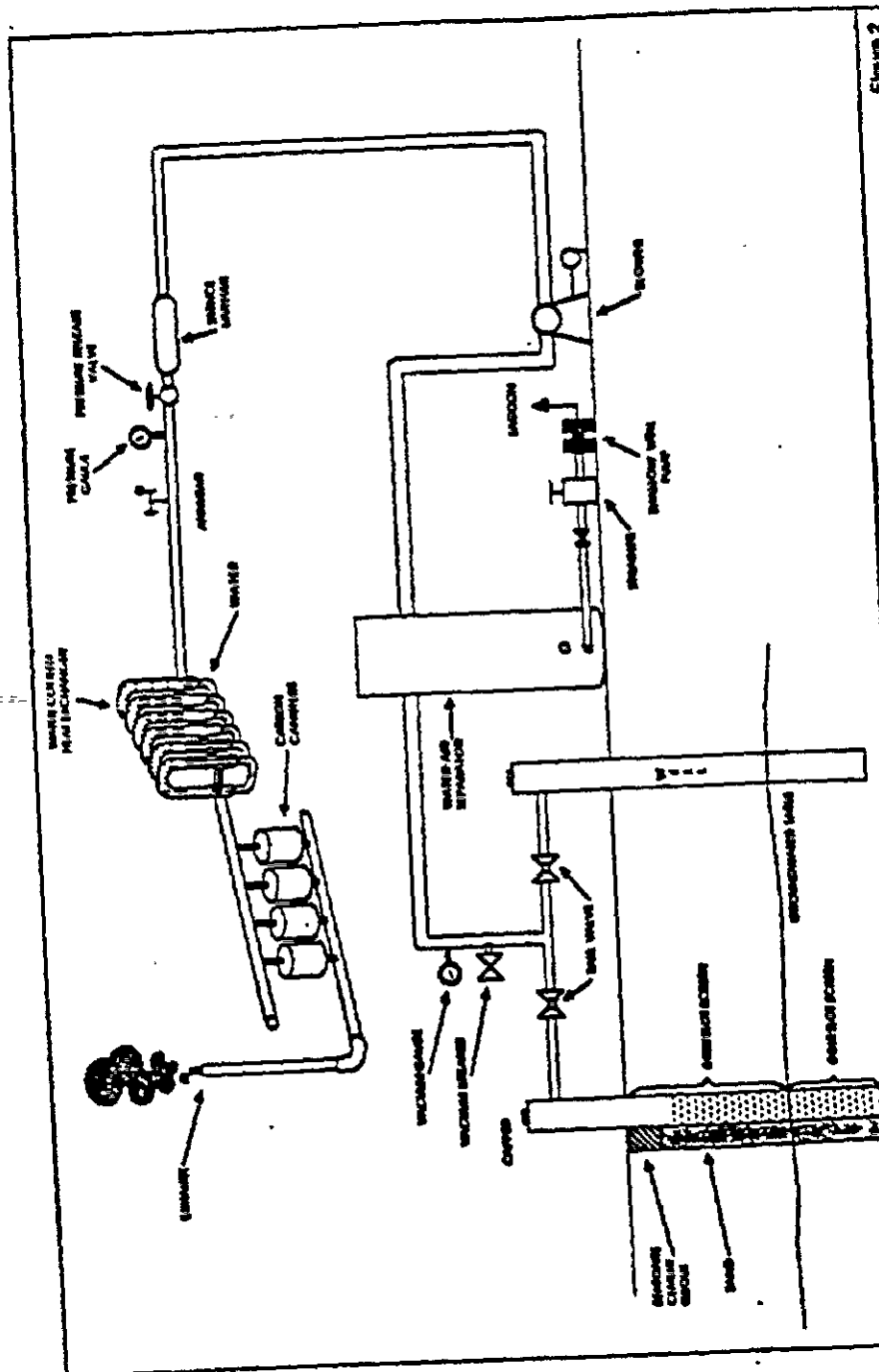


Figure 2

Process Flow Diagram of Vacuum Extraction System

Henderson Fluid Pro-Design Activity Recommendations

CDM

environmental engineers, scientists
planners & management consultants

AR302251

HENDERSON ROAD SITE



Injection well



Proposed locations (approximate)
(# equals wells to be installed at each location)

CDM

environmental engineers, scientists
planners & management consultants

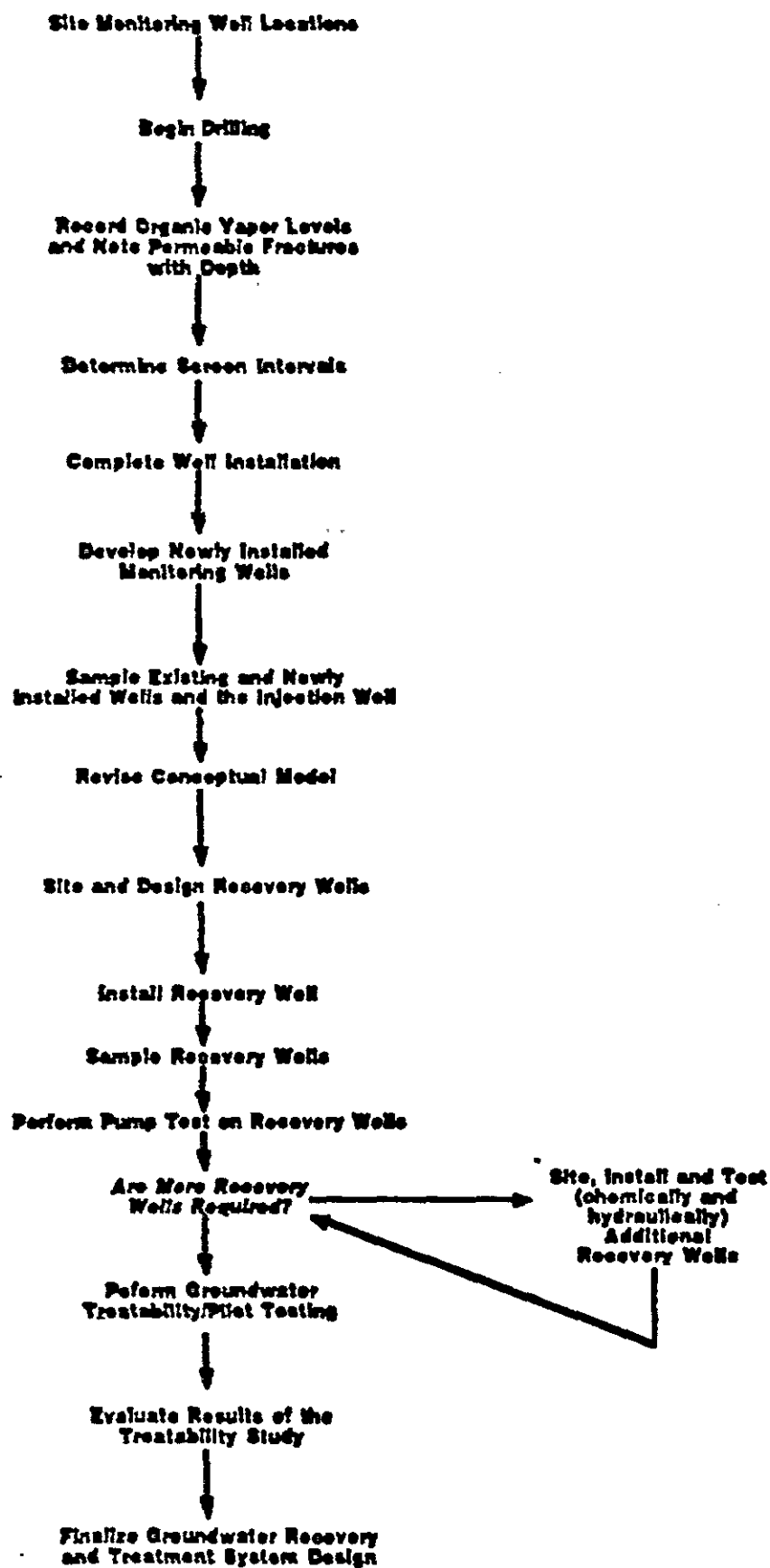
Figure 3

Saturated Zone Monitoring Locations

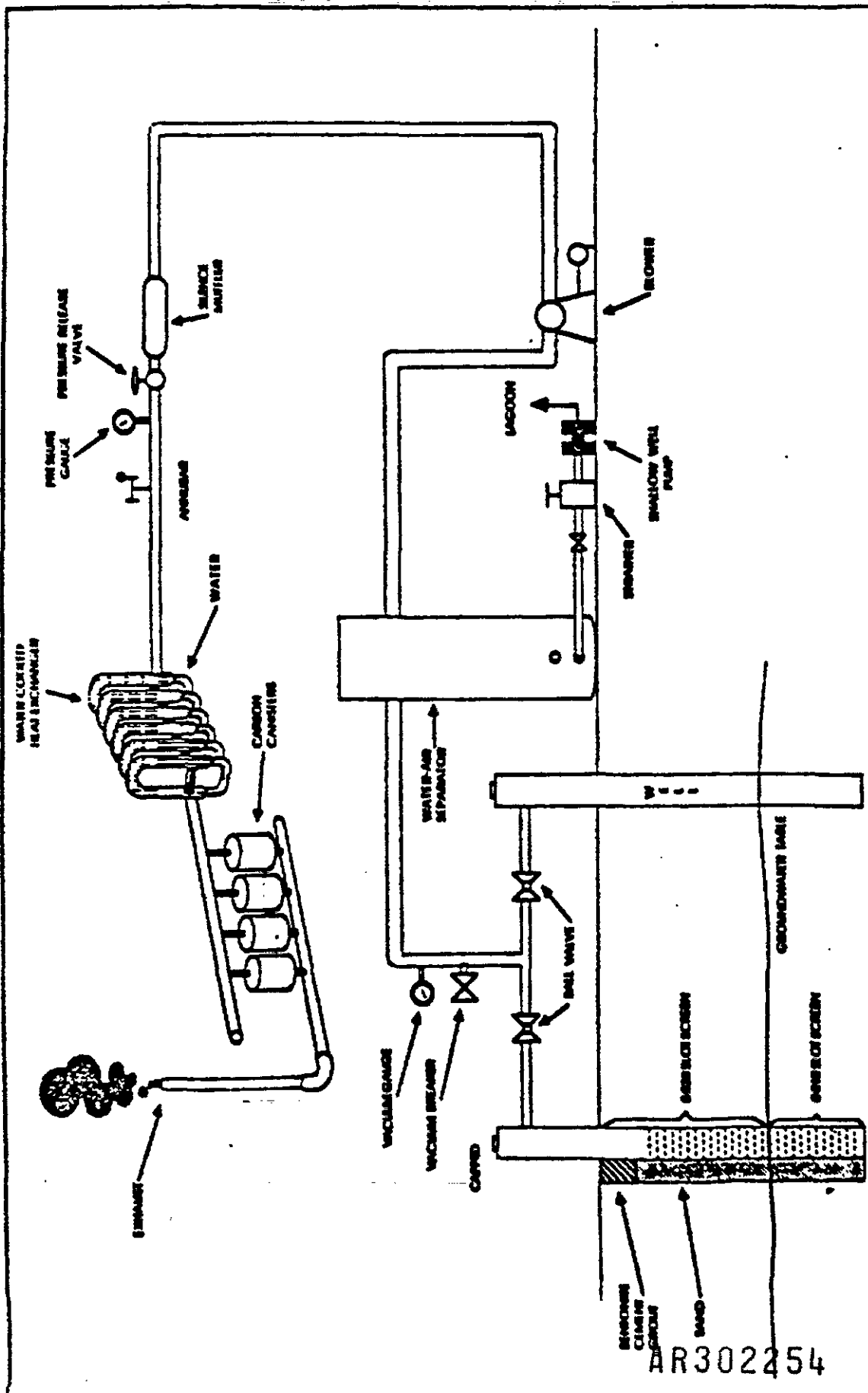
Henderson Road Pre-Design Activity Recommendations

AR302252

Detailed Progress of Events for Saturated Zone Investigation



AR302253



AR302254

Figure 2

Process Flow Diagram of Vacuum Extraction System

Henderson Road Pre-Design Activity Recommendations

CDM

environmental engineers, scientists
owners & management consultants

TABLE 1
TOTAL ACTIVITY COST ESTIMATE SUMMARY

Drilling and Monitoring Well Installations	\$ 600,000
Level 3 Health and Safety Contingency for Drilling	300,000
Down hole Logging (at 12 locations)	7,000
On site Gas Chromatograph Rental (for 90 days)	10,000
Laboratory analytical Services	56,430
Vacuum Extraction Testing (Equipment only, for 1 month)	90,000
Downhole Gas Sampling Equipment	<u>4,500</u>
SUB-CONTRACTOR AND EQUIPMENT TOTAL	\$1,067,930

LOE for Field Activities

Saturated and Unsaturated Zone Investigations	3,640 manhours
Vacuum Extraction Testing	<u>2,016 manhours</u>
TOTAL	5,656 manhours

Per Diem (\$90/day/person)

Saturated and Unsaturated Zone Investigations 300 man days x \$90	\$ 27,000
Vacuum Extraction Testing 140 man days x \$90	<u>12,600</u>
TOTAL	\$ 39,600

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TABLE 2
TASK COST SUMMARY

Injection Well Investigation

o Drilling Cost to Ream Injection Well (level B)	\$10,500
o Downhole Logging Costs (12 wells)	7,000
o 1 Round of VOA Samples at Existing Monitoring Wells	<u>4,390</u>
SUBCONTRACTOR AND EQUIPMENT SUBTOTAL	\$21,890

o *LOE Estimate

4 people x 10hrs/day x 6 days	<u>240 manhours</u>
TOTAL	240 manhours

Unsaturated Zone Investigation

o Drilling and Installation of 8 on-site shallow Monitoring Wells with Coring (level B)	\$236,610
o Laboratory Analytical Services	10,040
o Vacuum Extraction System Testing (w/out LOE)	102,600
o On-Site Gas Chromatograph Rental	10,000
o Downhole Gas Sampling Equipment	<u>4,500</u>
SUBCONTRACTOR AND EQUIPMENT SUBTOTAL	\$363,750

o *LOE Estimate

Vacuum Extraction Testing	2,016 manhours
Drilling and Well Installation	
40 days x 4 people x 10hrs/day	1,600 manhours
(assume level B with 2 coring rigs)	<u> </u>
TOTAL	3,616 manhours

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Table 2
Task Cost Summary
(continued)

Saturated Zone Investigation

o Drilling and Monitoring Well Installation of 21 monitoring wells (level B)	\$641,591
o Laboratory Analytical Services	
- New wells (saturated zone)	21,000
- Remaining Wells on-site	<u>21,000</u>
SUBCONTRACTOR COSTS	\$683,595

o *LOE Estimate

Drilling - 10hrs/day x 2 people x 60 days (assuming level C with 2 rigs)	1,200 manhours
Final Sampling - 10 hrs/day x 10 days x 6 people	<u>600 manhours</u>
TOTAL	1,800 manhours

Aquifer Hydraulic Testing Investigation

o Injection Well Installations	+
o Hydrologic and Chemical Testing of all Wells	+

*Total LOE Estimate

Injection Well Investigation	240 manhours
Unsaturated Zone Investigation	3,616 manhours
Saturated Zone Investigation	1,800 manhours
Aquifer Hydraulic Testing Investigation	<u>NA</u>
TOTAL	5,656 manhours

* At this time, professional dollar equivalents for hourly charges are not available for these activity recommendations.

+ These costs are not included due to the extreme variables involved in calculation.

(FS19/48)

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TABLE 3
CONTRACTOR AND EQUIPMENT COST CALCULATIONS

DRILLING COSTS

<u>Item #</u>	<u>Estimated Quantity</u>	<u>Item Description</u>	<u>Unit Cost</u>	<u>Cost/Item</u>
1	1	Mob/Demob	L.S.	\$ 50,000
2	200	Drums (for cuttings containment and movement on-site)	\$ 80/each	16,000
3	2000 lf	Overburden Drilling o Mud Rotary w/10' interval split spoons, 1 shelby tube, install 8" temporary casing	\$ 40/ft.	80,000
4	680 lf	Continuous NX coring w/ "Wire-line" technique	\$ 50/ft.	34,000
5	5670 lf	Air rotary to ream pilot holes from coring and/or advance boreholes for well installations (includes grout, gravel, & bentonite)	\$ 35/ft.	198,450
6		Materials		
a.	820 lf	o 4", Type 304, S.S. Screen	\$ 80/ft.	65,600
b.	6658 lf	o 4", PVC, Sch. 40 Riser	\$ 15/ft.	99,870
c.	29 lf	o Black Steel Protector Casings	\$200/each	5,800
7	82 hours	Downtime for Environ. Sampling thru Core Barrel	\$150/hr	12,300
8	87 hours	Steam Cleaning Equipment	\$200/hr.	17,400
9	87 hours	Well Development	\$150/hr.	<u>13,050</u>
		Sub-Total		\$592,470
			(approximately \$600,000)	
10		H & S Multiplier		
-		o Level C (on items 4,5,8 and 9) x 0.25	=	\$148,117
-		o Level B (on items 4,5,8 and 9) x 0.50	=	<u>296,235</u>
		Total (w/ level B H&S)		\$888,705
			(approximately \$900,000)	

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TABLE 3 (CONTINUED)

DRILLING ESTIMATE BACKUP

Assumptions for Core Drilling Estimates:

- Overburden thickness on-site = 40 ft.
- Rock thickness (Unsaturated) = 85 ft.
- Depth to water = 125' bgl
- 8 shallow wells to have coring completed
- 50' screens installed 10' into water
- Drilling depth will be 15' below the water table - and backfilled (room for minimal cave in)
- 1.0 hr. allowed for each environmental sample for downtime plus 20%
- 3 hours per well for Well Development

Assumptions for Off-site or Saturated Zone Monitoring Wells

- 20 foot screens installed at separate water bearing zones (150', 250', and 450'). Depths provided are conservative estimates that may be shallower
- All cuttings to be contained from all wells.
- 3 hours per well for steam cleaning due to varying drill rigs and methods used. Precaution against cross-contaminating the water bearing units
- Overburden thickness off-site = 80'
- No coring for off-site or deeper wells
- 8 deep wells (450')
8 medium wells (250') o To be installed at 8 locations
5 shallow wells (150')

Overburden Drilling Thickness:

- 8 on-site wells x 40' = 320 feet
- 21 off-site deeper wells x 80' = 1680 feet
- 2000 feet

Coring length:

- 8 on-site wells x 85' = 680'

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TABLE 3 (CONTINUED)

Air Rotary Length

- 8 on-site wells x 100' = 800'
- 5 off-site shallow wells x (150-80 = 70') = 350'
- 8 medium wells x (250-80 = 170') = 1360'
- 8 deep wells x (450-80 = 370') = 2960'

5470'

Additional footage for I.W.

200'
5670'

Materials:

S.S. Screen:

- 21 off-site wells x 20' each = 420'
- 8 on-site wells x 50' each = 400'

820'

Riser (PVC):

- On-site wells: 140' - 50' screen = 90' + 2' riser = 92' x 8 = 736'
- 5 off-site shallow wells = 140' - 20' = 120' + 2' riser = 122 x 5 = 610'
- 8 off-site medium wells = 250' - 20' = 230' + 2' = 232' x 8 = 1856'
- 8 off-site deep wells = 450' - 20' = 430' + 2' = 432' x 8 = 3456'

6658'

Downtime:

- 680 feet of coring in 10' sections = 68 core samples
- 68 core samples collected thus 68 gas samples collected. Allow a factor of 1.2 hours for each sample thus 68 x 1.2 = 81.6 = 82 hours

Decon:

- Allow 3 hours per well thus 29 wells x 3 = 87 hours

Well Development:

- Allow 3 hours per well thus 29 x 3 = 87 hours

Drums:

- Overburden 8 3/4" borings x 2000' /V = (3.14)(0.1329) = 0.417 ft² x (2000') = 835 ft³ x 7.48 gal/ft³ = 6247 gal
- Rock boring 6" x 5470' 1f /V = (3.14)(0.0625) = (0.0196 ft²)x(5470 ft.) = 1074 ft³ x 7.48 gal/ft³ = 8034 gal

6247 gallons
+ 8034 gallons
14281 gallons x 1 drum/50 gal = 285 drums

AR302260

TABLE 3 (CONTINUED)

LABORATORY ANALYTICAL SERVICES

<u>Item</u>	<u>Unit Cost</u>	<u>Number of Samples</u>	<u>Totals</u>
<u>Injection Well Waste - full TCL</u>	\$ 1,000	1	\$ 1,000
<u>Existing Monitoring Wells - VOAs</u>	220	12	2,640
Floating product - TCL organics	750	1	750
<u>Unsaturated Zone Wells</u>			
Sediment samples - VOAs (3/well)	220	24	5,280
Air samples at 10' intervals - on-site GC (costed separately)	---	---	---
Floating product - (assume 4 wells)			
TCL organics	750	4	3,000
Water samples - VOAs on-site GC	220	8	1,760
<u>Saturated Zone Wells</u>			
Water samples - full TCL	1,000	21	21,000
<u>Final Sampling</u>			
Unsaturated wells - full TCL	1,000	8	8,000
Existing wells - full TCL	1,000	12	12,000
Injection well - full TCL	1,000	1	1,000
<u>Total Analytical Costs</u>			\$56,430

DOWNHOLE LOGGING

Assumptions:

- 12 wells to be logged
 - o Injection Well or Replacement Well
 - o 3 on-site existing wells
 - o 8 proposed shallow monitoring wells

Allow 2 hours per well for logging each well

Allow 2 hours per well for deconing the equipment

Thus 4 hours per well x 12 locations = 48 hours

Hourly Rate = \$90/hour x 48 hours = \$4320

Assume 4 separate trips to the site to complete the downhole logging activities. Each separate trip costs \$500 for Mob/Demob.

Thus 4 trips x \$500 (Mob/Demob) = \$2000

Summary:

12 wells x 4 hours/wells x \$90/hour	=	\$4,320
4 trips to site x \$500 Mob/Demob	=	2,000
		<u>\$6,320</u>

Budget Safety Factor of 10X

Total Downhole Logging Cost

x 1.10

\$6,952

(approximately \$7,000)

AR302261